Long Range Sediment Tomography

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LONG-TERM GOALS

Our long-term objective is to develop an inversion scheme for the estimation of acoustic properties of sediments in shallow water using broadband explosive sources.

OBJECTIVES

- Design and implement an inversion scheme for range and depth dependent tomographic mapping of sediments in the East China Sea as part of the ASIAEX experiment.
- Validate the inversion with other measurements in the region including gravity cores, chirp sonar, etc.
- Quantify the resolution and accuracy of the inversions.
- Investigate the potential of this method for other shallow water areas as a rapid environmental assessment tool.

APPROACH

A scheme for the estimation of compressional wave speed and attenuation has been developed using broadband explosive sources. Sediment compressional speeds were estimated using hybrid methods based on the modal dispersion behavior of broadband acoustic propagation. In this hybrid scheme, we have used Genetic Algorithm (GA) as the main search tool. Local optimization tools were used to fine-tune the inversion. This scheme is discussed in detail by Potty, Miller, Lynch and Smith[1]. Attenuation values were estimated by another inversion scheme based on modal amplitude ratios. In addition to sediment properties other parameters such as bathymetry, source-receiver range, source depth, receiver depth and source level were also treated as unknowns in this inversion scheme. Source receiver range was also estimated using the travel time differences of different modes and the calculated group speed values. This inversion scheme as applied to the data from the Shelf Break Primer Experiment conducted in summer of 1996 is described in detail by Potty, Miller and Lynch[2]. The results of this inversion were successfully compared with core data from Atlantic Margin Coring (AMCOR) project and gravity cores. When we have a number of explosives deployed over a large area this inversion scheme can be applied along each source- receiver path. Hence we can come up with a 3-D description of the sediment properties over an area[3].

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14. ABSTRACT
Our long-term objective is to develop an inversion scheme for the estimation of acoustic properties of sediments in shallow water using broadband explosive sources.

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Using the experience gained from the PRIMER experiment, we planned a similar study at the ASIAEX site in the summer of 2001. The major experimental effort was at the East China Sea (ECS). A number of gravity cores were taken from the experimental site in 2000 which were analyzed on board of the ship to get the compressional wave speeds. In addition geological profiling was also carried out using chirp sonar and water gun. Another coring cruise was conducted after the main experiment in August 2001 to collect few piston cores. These cores were analyzed later by KORDI and results are awaited.

WORK COMPLETED

The design and implementation of the experiment has been successfully completed in May-June 2001. The APL/UW vertical line array, consisting of 16 hydrophones and the URI data acquisition system were used to acquire the data. The VLA was deployed from R/V Melville and the explosives were deployed from the Chinese research vessel Shi Yan 2. Over 200 shots of weights 38 g and 1000 g were deployed along circular and radial pattern. The locations of these shots were recorded using a handheld GPS. These shots were set to explode at a depth of 50 m but we expect some variation in the source depths.

Improved time-frequency analysis techniques were developed[4] and applied to the ECS data. This new technique, Matching Pursuit Decomposition (MPD), has a better resolution which will produce better quality data for our inversions. Figure 1 shows the time- frequency diagrams produced by wavelet method and MPD. We have also modified our inversion scheme to match the frequencies and arrival times corresponding to the Airy Phase. We have found that the Airy Phase is highly sensitive to the sediment properties and making use of the data at or close to it will yield more accurate estimates of the sediment properties.

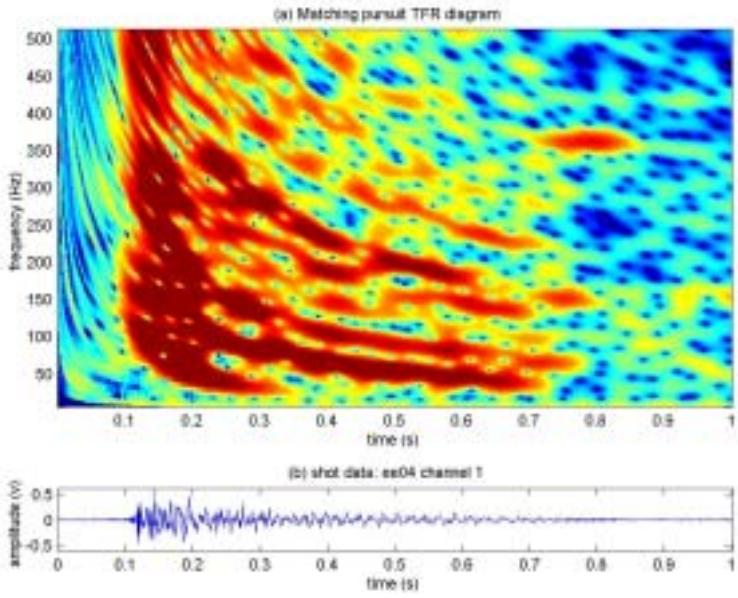

Figure 1. Explosive signal and the time- frequency diagram produced using MPD

RESULTS

Figure 2 shows the early results from the study. The acoustic signals received at the Yellow Sea array from explosive charges at 30 km were used for the inversions. The figure shows the contours of the surficial sediment velocities and the gravity core data. The stars in the figure represent the locations of the Wide Band Source deployment. The location of the receiver was approximately at the center of the circle. The gravity core data shows different sediment velocities on two halves of the circular deployment. The surficial sediment velocity is of the order of 1600- 1610 m/s on the left half of the circle whereas it is higher (1610 to 1680 m/s) on the right half). The gravity cores penetrated down to a maximum depth of 0.50 m. The inversions estimated higher values compared to gravity core data. A two layer (surface layer and basement) sediment model was assumed for the inversion. The results shown in Figure 2 are the average compressional speed in the surface layer i.e., an average over a depth of 4 m. More detailed inversions are being carried out at present.

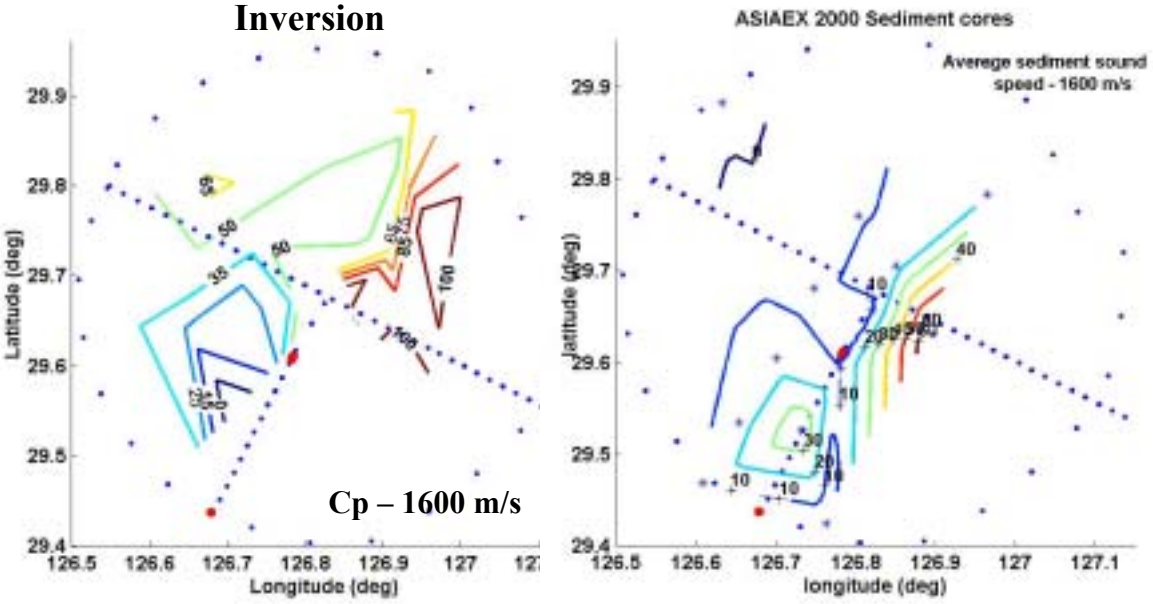

Figure 2. Left panel shows the compressional wave speed contours obtained from preliminary inversions. The gravity core data is shown in the right panel.

IMPACT/APPLICATIONS

This inversion scheme using explosive sources is suitable for rapid estimation of acoustic properties of sediments in shallow water. This method is cost effective as a single hydrophone and air-deployed explosives can provide the data. Using multiple sources and receivers sediment properties over an area can be mapped.

TRANSITIONS

The sediment parameters obtained by this inversion can be used for the forward modeling efforts at East China Sea. In addition, this technique can be applied to data from a single SUS charge recorded on a single sonobuoy making the transition to fleet use very easy.

REFERENCES

1. G. R. Potty, J. H. Miller, J. F. Lynch and K. B. Smith, "Tomographic inversion for sediment parameters in shallow water," J. Acoust. Am. 108 (3), 973-986, (2000).

2. G. R. Potty, J. H. Miller and J. F. Lynch, "Inversion of sediment geoacoustic properties at the New England Bight," J. Acoust. Am. (under revision).

3. G. R. Potty and J. H. Miller, "Tomographic mapping of sediments in shallow water,""IEEE. J. Ocean. Engg. (under revision)

4. C- S. Chen, "Time- frequency analysis of underwater acoustic signals in the 2001 ASIAEX – East China Sea experiment," M. S Thesis, University of Rhode Island, 2002.

PUBLICATIONS

1. G. R. Potty, J. H. Miller and J. F. Lynch, "Inversion of sediment geoacoustic properties at the New England Bight," J. Acoust. Am. (under revision).

2. G. R. Potty and J. H. Miller, "Tomographic mapping of sediments in shallow water,""IEEE. J. Ocean. Engg. (under revision)

3. K. B. Smith, C. W. Miller, A. F. D'Agostino, B. Sperry, J. H. Miller and G. R. Potty, "Three-dimensional propagation effects near the mid-Atlantic Bight shelf break (L)," J. Acoust. Am. 112(2), 373-376, 2002.

4. C- S. Chen, "Time- frequency analysis of underwater acoustic signals in the 2001 ASIAEX – East China Sea experiment," M. S Thesis, University of Rhode Island, 2002.

PRESENTATIONS/ CONFERENCE PROCEEDINGS

1. G. R. Potty, J. H. Miller, C- S Chen and C. Lazauski "Broad-band non-linear inversions in shallow water for geoacoustic parameters," First International Conference on Inverse Problems: Modeling and Simulation, Fethiye, Turkey, 2002 (Invited talk).

2. C. Lazauski, G. R. Potty, J. H. Miller, C-S. Chen and P. Dahl, "Sediment tomography in the East China Sea: Compressional wave speed and attenuation inversions from modal travel time dispersion and Airy phase measurements," J. Acoust. Am., 111(5), p.2388, 2001.

3. G. R. Potty, J. H. Miller, C- S Chen and C. Lazauski "Sediment tomography in the East China Sea: Preliminary results, J. Acoust. Am., 110(5), p.2724, 2001.